



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Zero Energy Buildings

Lew W. Pratsch
U.S. Department of Energy
Systems Approach to Solar Workshop
Maritime Institute, Linthicum MD
December 17, 2002





ZEB Systems Approach to Management

- Meet National objectives articulated by Secretary and Assistant Secretary
- Optimize ZEB via building, renewable energy and utility sector R&D
- Initial emphasis--the residential sector, later commercial buildings
- Engage industry via ZEB Teams & aggressive incremental advancements



National Objectives: The Secretary

- Challenged DOE to take a bolder approach to our work
- He directed us to focus our efforts on programs that “revolutionize how we approach conservation and energy efficiency”
- He challenged us to “leapfrog the status quo” and pursue “dramatic environmental benefits” (The Mission and Priorities of the Department)



EERE Strategic Plan Goals & Success Indicators

- Goals
 - #1—Dramatically reduce, or even end, dependence on foreign oil
 - #2—Reduce the burden of energy prices on the disadvantaged
- Success Indicators
 - #3—Renewable energy is widely cost-competitive within the next 20 years
 - #4—A significant portion of the Nation's ...power needs can be served by 2030 with clean, reliable & efficient distributed power
 - #5—Cost-competitive new buildings, which create as much energy as they use, are widely available within the next 20 years



Zero Energy Building Vision & Goals

- America's new homes and commercial buildings will produce as much energy as they use. These buildings will be affordable, durable, healthy, productive and more comfortable. (Adapted from Zero Energy Home Roadmap)
- Goals:
 - Affordable residential ZEB available by 2010
 - Commercial ZEB available by 2015
- Accomplishing Vision and Goals depends on a systems approach to buildings that satisfies multiple criteria



ZEB Strategic Approach

- Develop and integrate technologies to enable zero (net) energy use in buildings
- Build on Building America to dramatically reduce energy use and related emissions in the near term for new buildings
- Guide policies that stimulate demand for Zero Energy Buildings, enhance energy security, reduce pollution, and eliminate summer peak load
- Success depends on ability to integrate & optimize multiple technologies in different climates and building types that have different market constraints/opportunities



ZEB Benefits

- Zero (net) Energy
- Zero Peak Load
- Zero Emissions
- Zero Utility Bill
- Zero Complaints (from new homebuyers & building occupants)
- And, affordable, durable, healthy, productive, and more comfortable



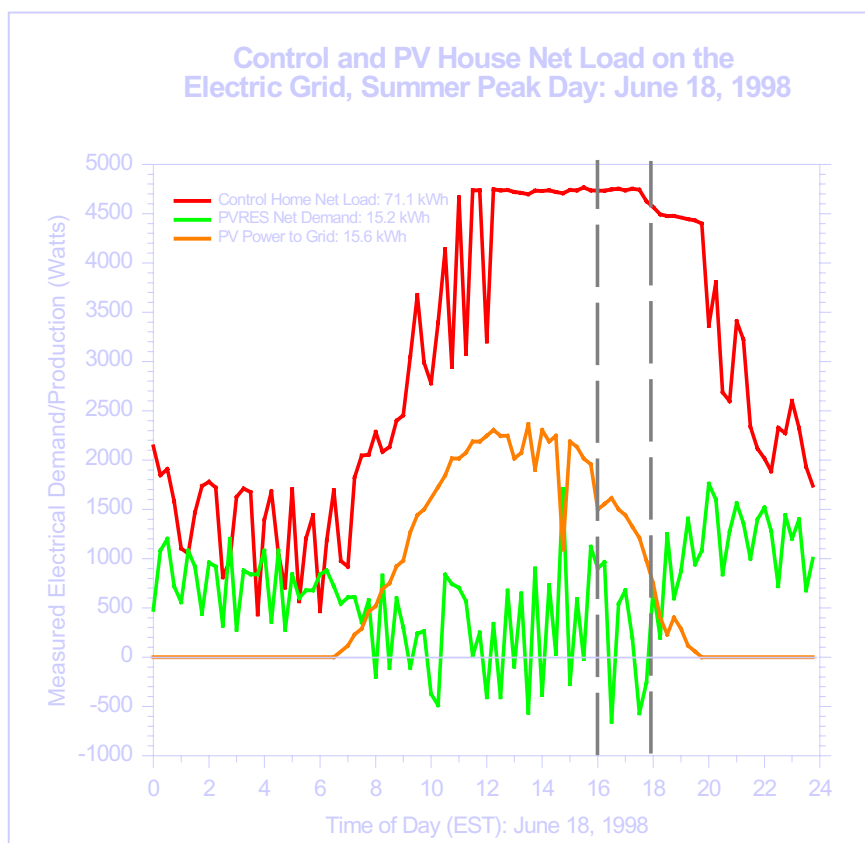
Energy Profile - Residential

- Year 2000 data
- Of 19.9 quads, 65% is electricity and 26% is natural gas
- Residences consume 20% of all U.S. energy
- A/C dominates utility peak loads

<u>End Use</u>	<u>Quad</u>	<u>%</u>
Space Heating	6.6	33%
Space Cooling	2.0	10%
Water Heating	3.0	15%
Lighting	1.2	6%
Refrigeration	1.7	9%
Wet Clean	0.9	5%
Cooking	0.9	5%
Electronics	1.0	5%
Computers	0.1	1%
Other	<u>0.7</u>	<u>3%</u>
Total	19.9	100%



Early Modeling: Improved Grid + Less Energy



Source: Florida Solar Energy Center (FSEC)

- Grid-connected PV system, solar water heating, & energy-efficient equipment.
- 4kW PV supplied most of the home's daytime electrical needs on peak summer days
- Hottest summer day ZEH used:
 - 72% less power to run its AC
 - 93% less utility-supplied power

Energy Savings			
	Power Use (kWh)	Net Power Use (kWh)	Monthly Cost of Power (\$)
Zero Energy Home	837	335	\$27
Control Home	1,839*	1,839*	\$147

*Air-conditioning only

Source: FSEC



Solar Patriot House

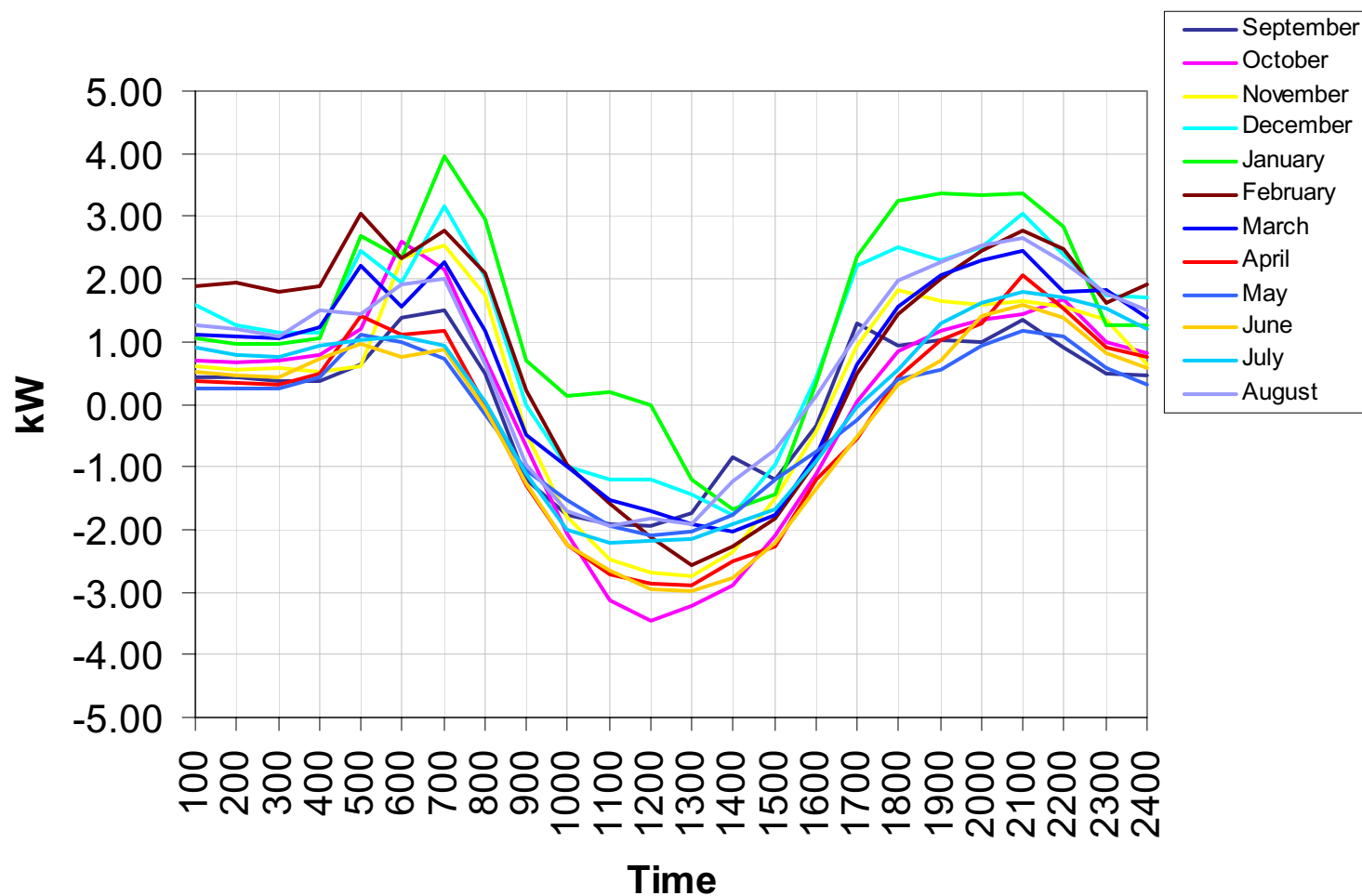
- 3000 sq. ft. + Top Floor & Basement
- Full complement of modern appliances
- Produced “82%” of energy onsite in first year
- Expect to achieve ZEB status in 2003
- Monitored past year by NREL





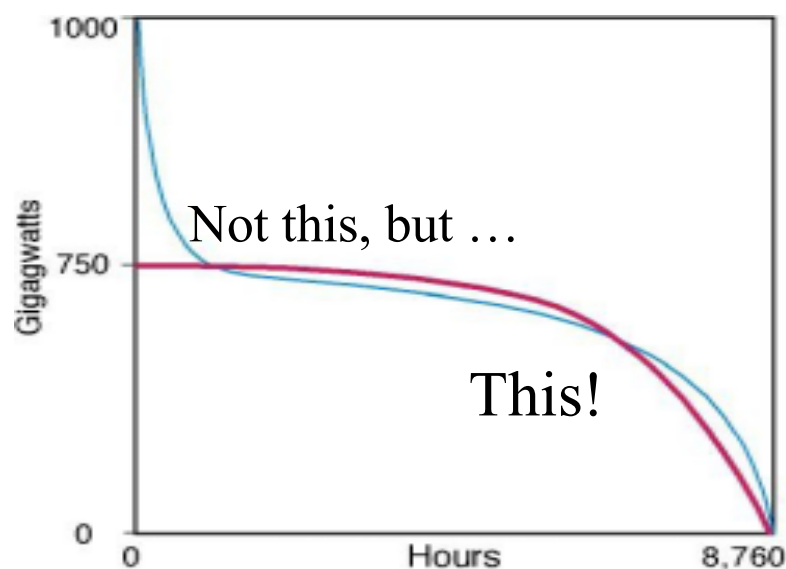
Solar Patriot House

Net Power Bought
Average Hourly Profile





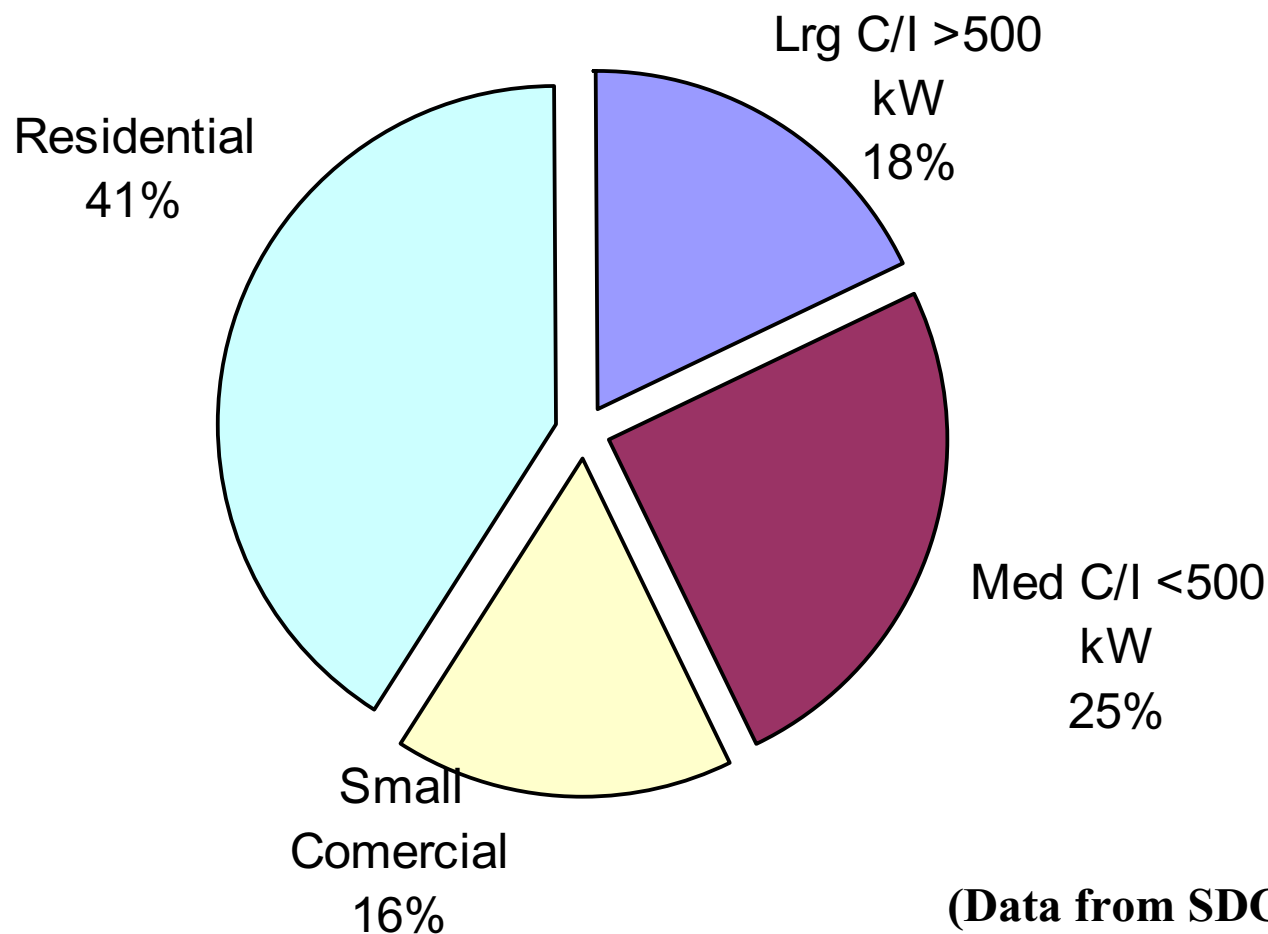
A “Flat” Load Profile Would Save Big \$



- Flattening the load curve could eliminate the need for ~20% or more of generation, transmission, and distribution capacity!
- A flatter load curve could change the types of power plants, how they operate, and overall fuel efficiency of the power system.
- A flatter load curve could reduce power costs and price volatility for all consumers.



Searching for Peak Savings



(Data from SDG&E 1999)



ZEH Homebuilder Teams

- Four ZEH teams awarded contracts this year
- Teams will design, build marketable prototypes, monitor, & build subdivisions
 - Consol (Morrison, Shea, WL Homes & Pardee)
 - Davis Energy Group (Centex)
 - NAHB (John Wesley Miller)
 - Steven Winter Associates (Beazer, Mercedes & Bradley)



Shea's High Performance Homes

- 306 homes under construction
- Homes about 40% better than Title 24
- All will have Solar Water Heaters
- About 100 will have 1.2 kw
- Many have option to upgrade to 2.4 kw
- 250 homes sold—will complete subdivision early
- Homes selling as fast as they can be built
- Solar features often mentioned one of top 3 reasons for purchase



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Shea's San Angelo Subdivision





Shea's Homebuyer Comments

- Energy-efficiency & solar features a “bonus” —a nice surprise
- “We feel the builders know what they are doing, so if they offer the solar as part of the package, there must be a reason.”
- “They are finally listening to what consumers want.”
- “All the builders should be doing it.”
- One homeowner was blown away—1200 sq ft condo had a higher utility bill than 4000 sq ft house



U.S. Department of Energy
Energy Efficiency and Renewable Energy

SunChoice™ Power Meter





Centex ZEB Home

- First ZEB Team Home
 - Open House—July 02
 - Davis Energy Group
 - Expects to have Zero Energy Bill
- Key Features
 - Photovoltaics--3.6 KW
 - Night Breeze (Smart Economizer)
 - Slab insulation
 - Window Shading
 - Cellulose insulation



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Centex ZEB House





John Wesley Miller

- Teaming with NAHB Research Center
- ZEB Groundbreaking—November 4, 2002
 - Includes 4 kw of solar electric
- 99 homes all have:
 - Utility guaranteed htg/clg bills @ about \$1/day
 - Solar water heaters & solar electric
 - Masonry walls for thermal storage
 - Pre-wired with cable TV/Fiber optics
 - Central vacuum & two car garages
 - Pedestrian-friendly neighborhood



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Armory Park Del Sol—Tucson, AZ





Tucson's* Time-of-Use Rate

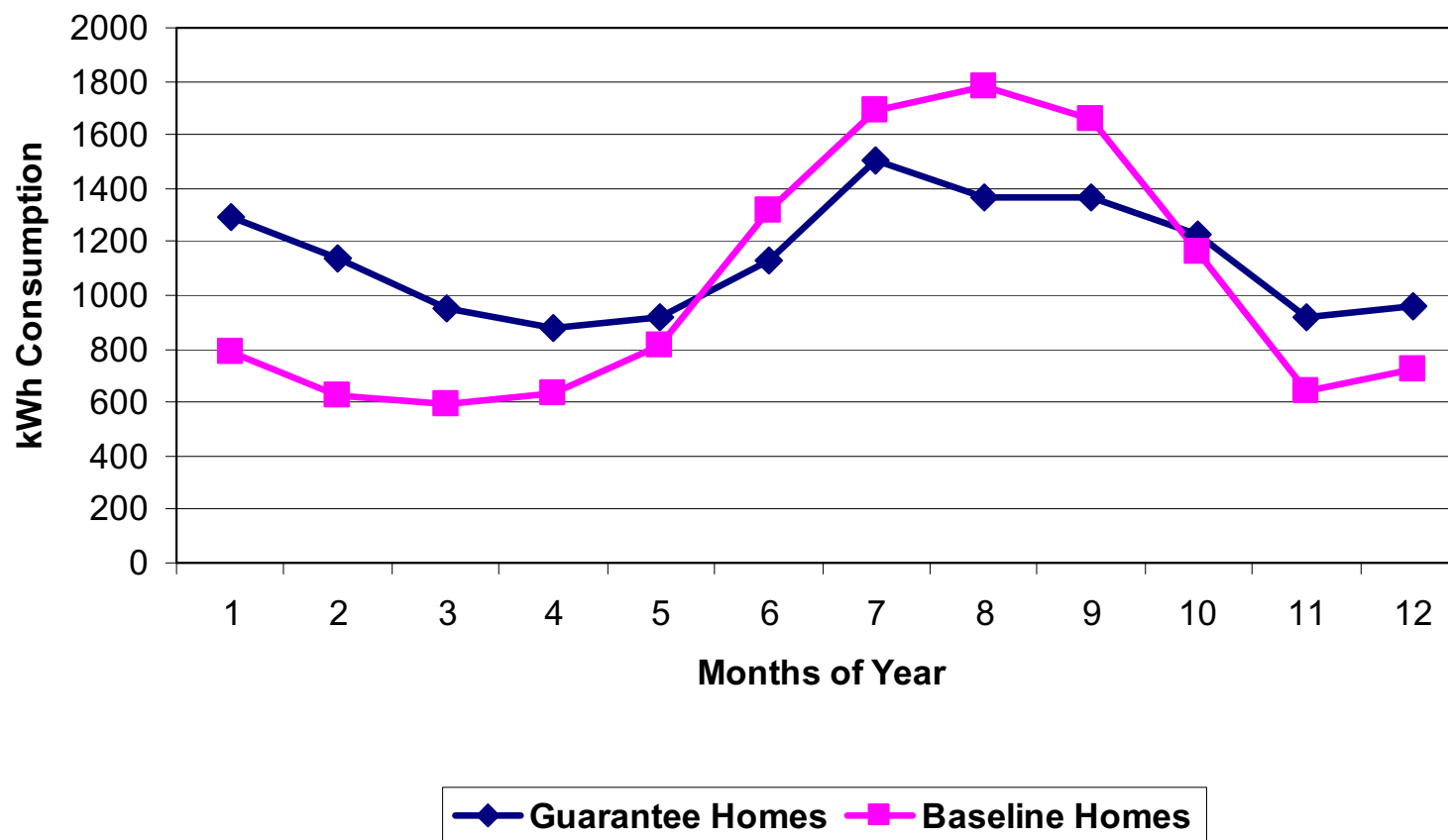
	Jun-Aug	May & Sep-Oct	Nov-Apr
On-peak kWh @	\$.18	\$.15	\$.10
Shoulder kWh	\$.12	\$.09	NA
Off-peak kWh	\$.06	\$.05	\$.03
Min bill/month	\$6.78		

*Tucson Electric Power Company



TEP's Residential T-O-U vs Control

**Guarantee vs Baseline Homes Total Sample
Year Ending July 2002
Both Samples Weather Normalized**





Roadmaps by EERE/Industry

- Window Industry Technology Roadmap
- Building Envelope Technology Roadmap
- Lighting Technology Roadmap
- HVAC & Refrigeration Roadmap
- Zero Energy Homes Roadmap
- Appliances and Equipment Roadmap
- The U.S. Photovoltaic Industry Roadmap
- Technology Pathways for the DOE Zero Energy Buildings Program (With DOE's labs)



Possible Solar Energy Tech. R&D

- Cut installed price of PV 50%
 - Lower-cost thin-film technologies
 - More reliable modules and systems
 - Improved manufacturing
- Develop polymer based solar water heater
- Develop polymer based solar space heating system
- Develop building integrated solar on roofing membrane
 - PV over thermal
 - PV & thermal side-by-side
- Low cost storage for critical needs
- Develop solar based combined heat & power system for commercial buildings



Astropower's SunChoice™ Solar Electric Home Power System

- New roof-integrated product with enhanced aesthetics, same reliability and performance
- Builder partners:
 - Shea,
 - Pardee,
 - Centex,
 - Standard Pacific,
 - Clarum,
 - US Home,
 - Lennar





Possible Buildings Technologies

- 70% reduction in building envelope energy use
 - Insulation/air infiltration
 - Advanced windows/automated exterior shading
 - Slab & foundation insulation
- Smaller, more efficient HVAC
 - Possibly no ductwork
- Individual room control for HVAC, lights
- Smart water heaters & appliances
- Wireless, automated systems
- Zero Energy commercial building analysis
- Codes & standards



Possible Zero Energy Home R&D

- ZEH Homebuilder Team Support
 - Build prototypes and subdivisions
 - Recommend R&D
- Zero Energy Home monitoring
 - Utility load curves/factors
 - Homebuyer satisfaction
- ZEH integration & optimization for various climates
- ZEH automation & system integration
 - Automatic operation of home's energy systems
 - Accommodate Time-of use rates
 - Interact with utility/weather
- Initial Zero Energy Commercial Building analysis



Residential Energy Saving Pgms.

- Energy Star Homes (EPA)
 - 30% better than code or 15% better than state code
- Building America (DOE)
 - New homes—40-70% reduct. in whole house energy use
 - Existing homes – 20-40% lower energy bill
- Zero Energy Homes (DOE)
 - ZEH-50 -- Cut utility bills 50% by 2004
 - ZEH-75 -- Cut bills 75% by 2007
 - ZEH-100 – Zero Energy Bill



Why should builders build ZEHs?

- “ZEHs can help builders compete smartly – not on the basis of cost – but on the basis of product differentiation, thereby expanding their sales in both the conventional home and higher margin markets.” Zero Energy Homes Roadmap—Final Draft, September 2002
- Sell two more houses per week!



ZEB Benefits

- By 2020 EIA projects buildings will consume 47 Quads
 - Today--High-efficiency homes about 5% of market
 - Establish new paradigm to drastically cut energy use
- First major program to fully integrate energy efficiency & renewable energy
- Ideal for time-of-use rates
- Improves grid by shedding summer peak load growth
- Positive cash-flow in mortgage



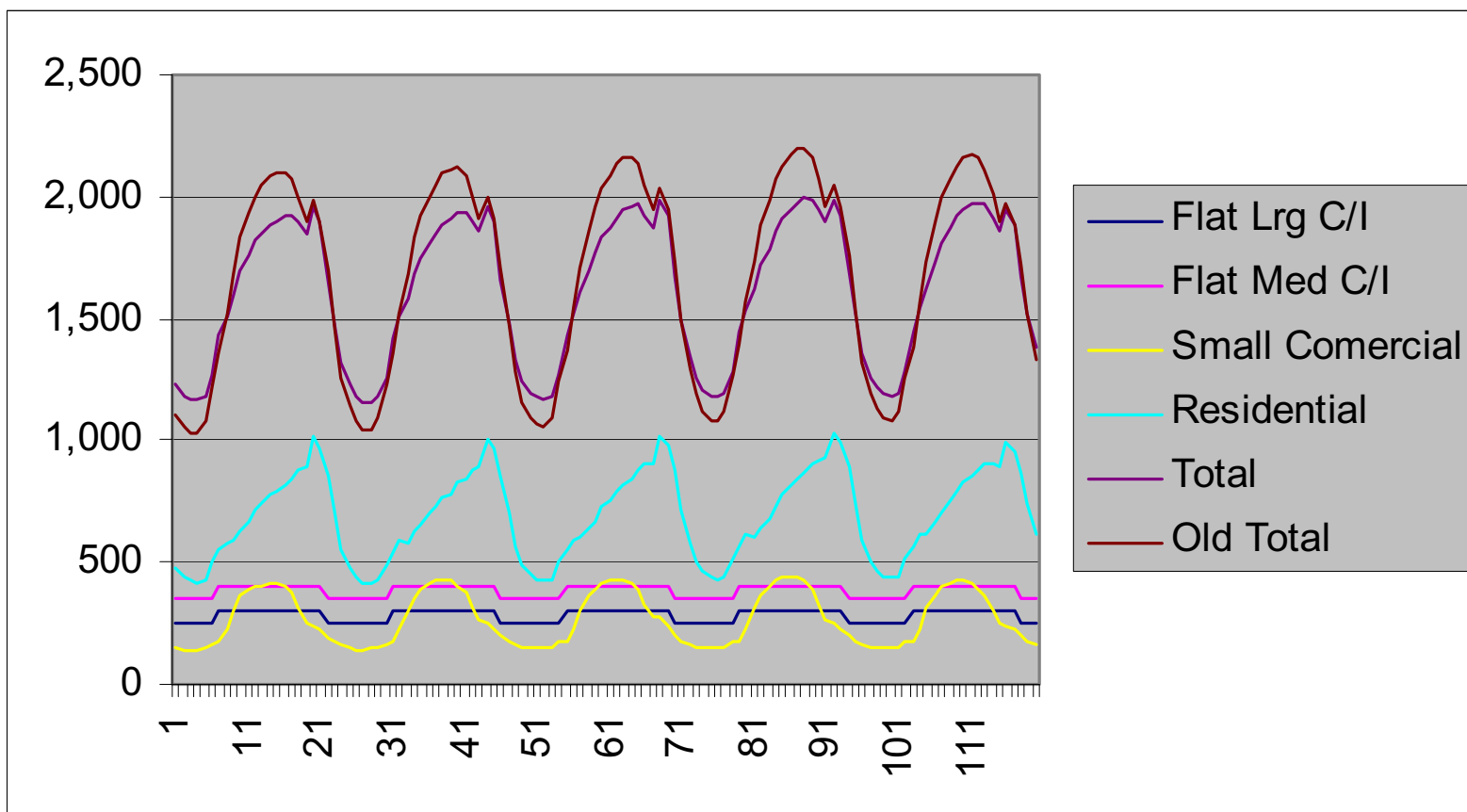
The ZEB Challenge

- Excellence in RD&D
- Excellence in design
- Excellence in construction
- Excellence in load management
- Excellence in marketing
- Excellence in comfort
- And, Industry excitement



Searching for Peak Savings

Medium & large C/I shave peaks





Searching for Peak Savings

Smart res. & small com. save day

